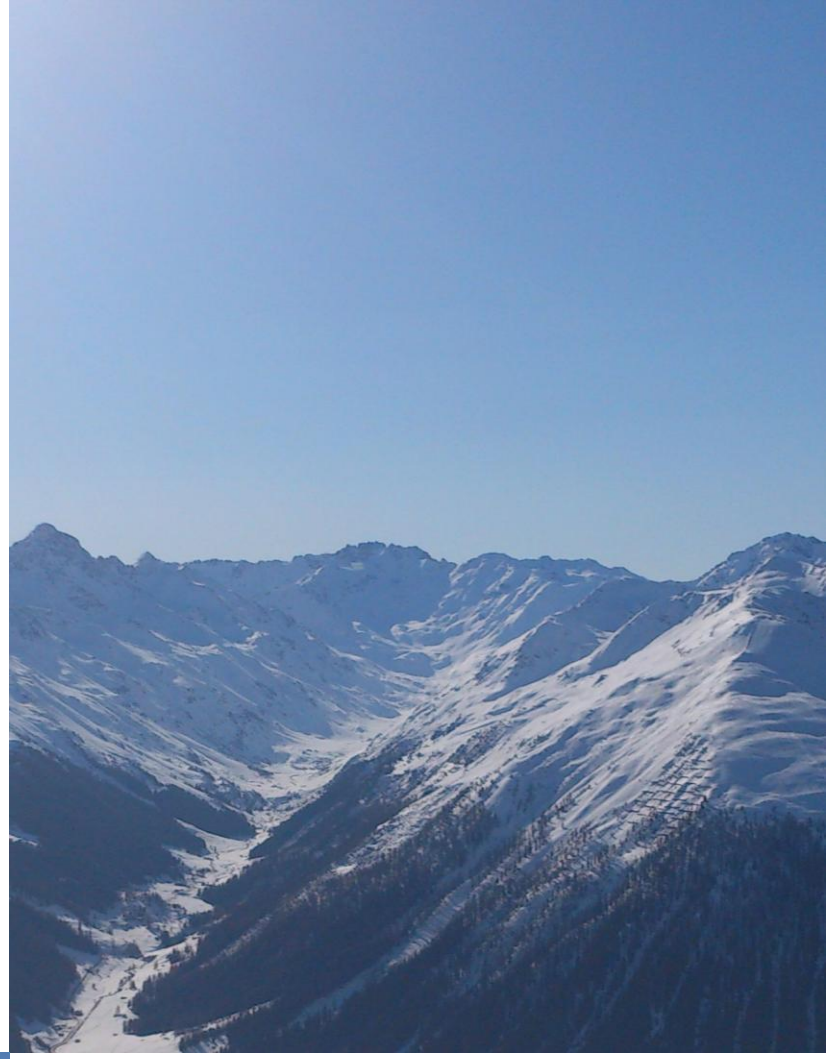
From snowfall…



… to snow accumulation

Franziska Gerber

3.9.2015, ICAM

Co-authors: R. Mott, J. Grazioli,
D. Wolfensberger, A. Berne
and M. Lehning

SLF

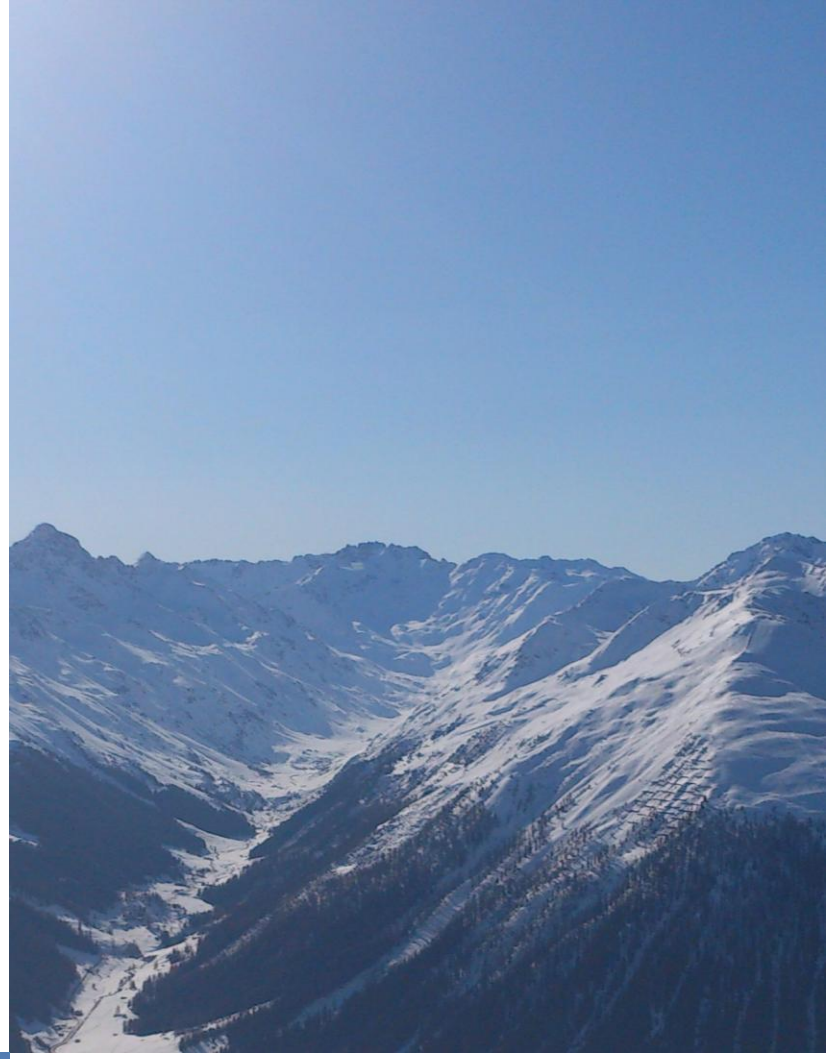
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

From snowfall…

- Parallel precipitation radar and TLS measurements
- Processes: snowfall and accumulation
- Methods
- The snowfall event at Easter 2015

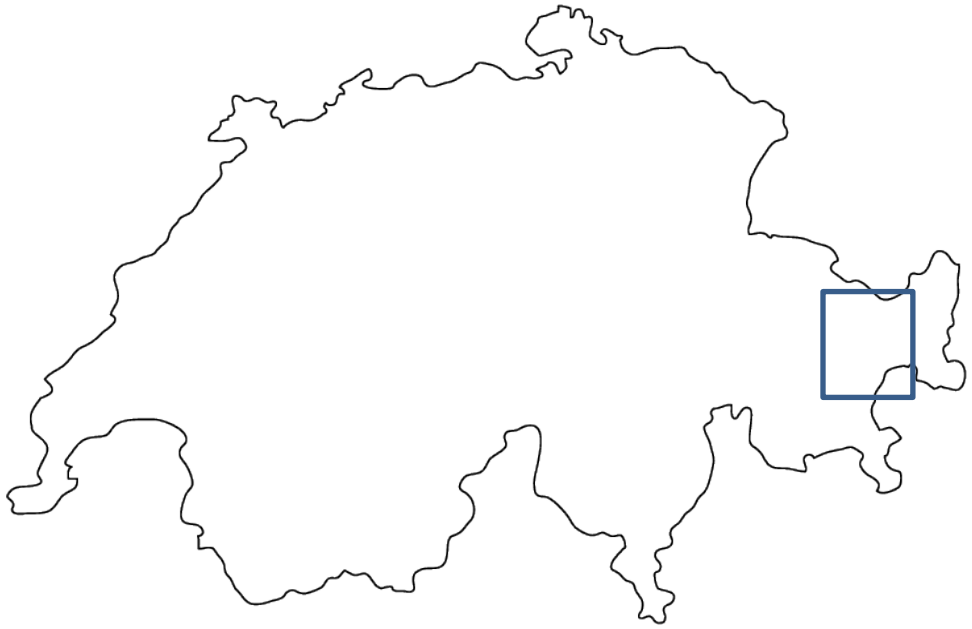
"Processes in lowest 1000 meters above ground are important"

… to snow accumulation

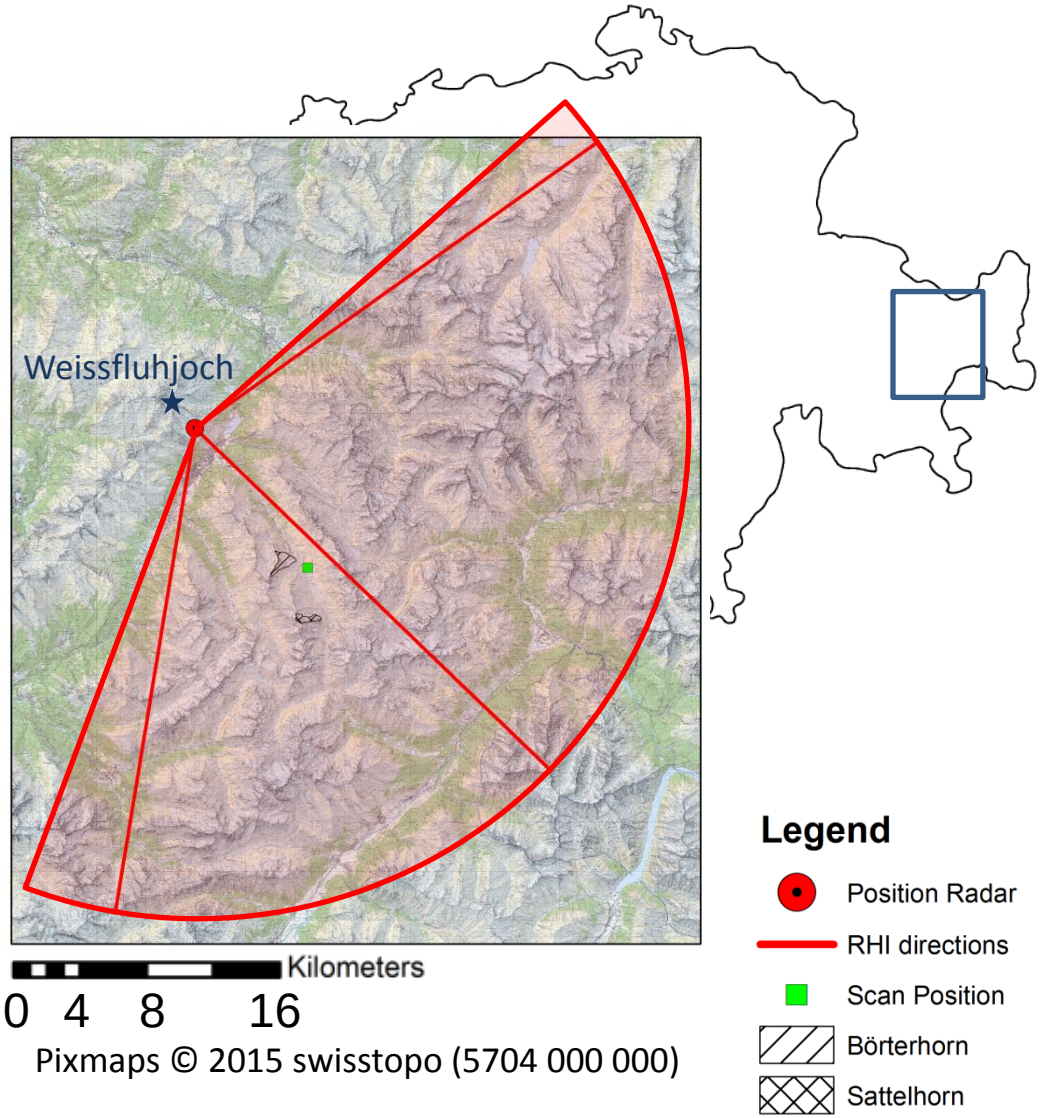


TLS: terrestrial laser scan

Parallel precipitation radar and TLS measurements

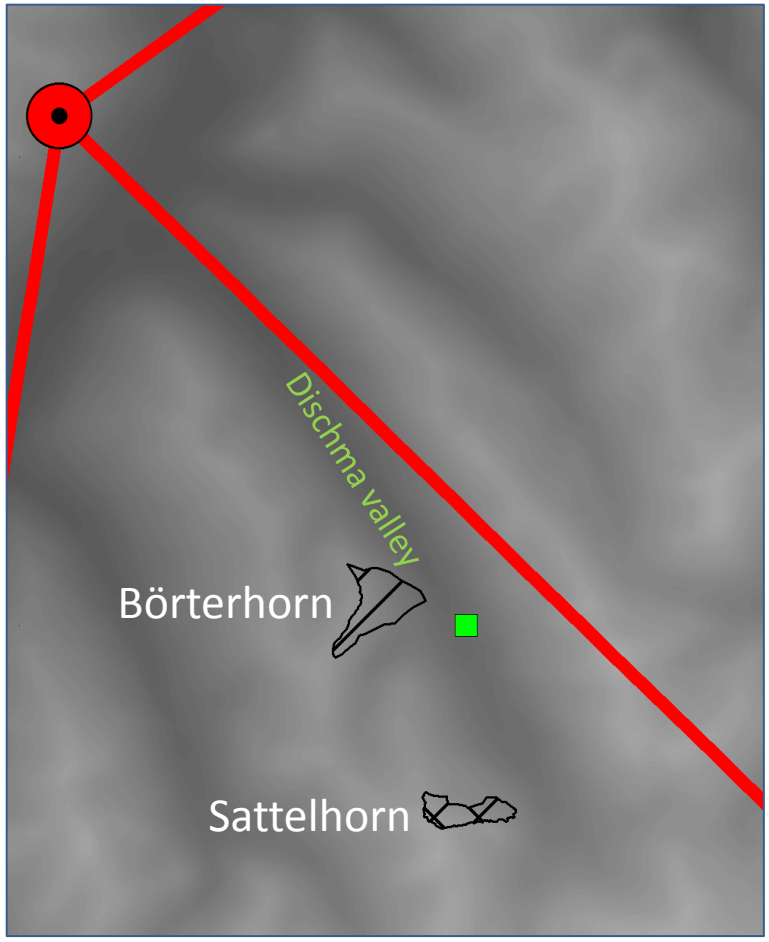


Parallel precipitation radar and TLS measurements



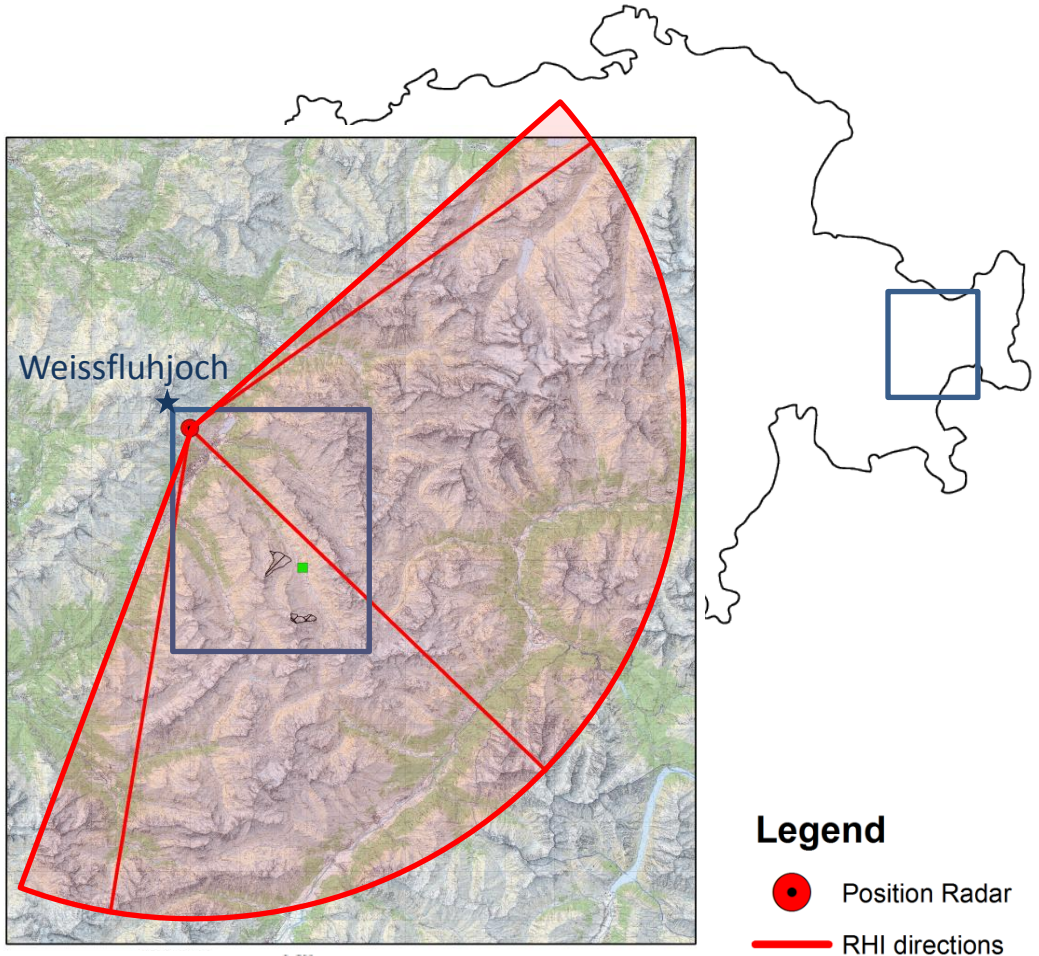
Parallel precipitation radar and TLS measurements

Dischma-Experiment



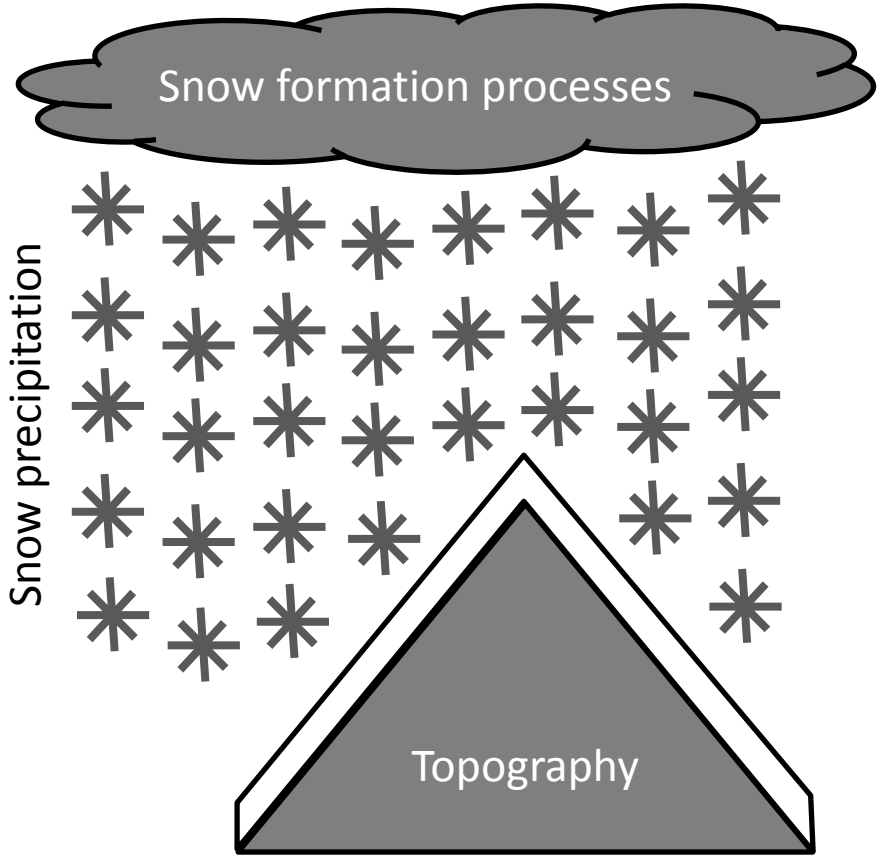
Kilometers

0 1 2 4 6 8

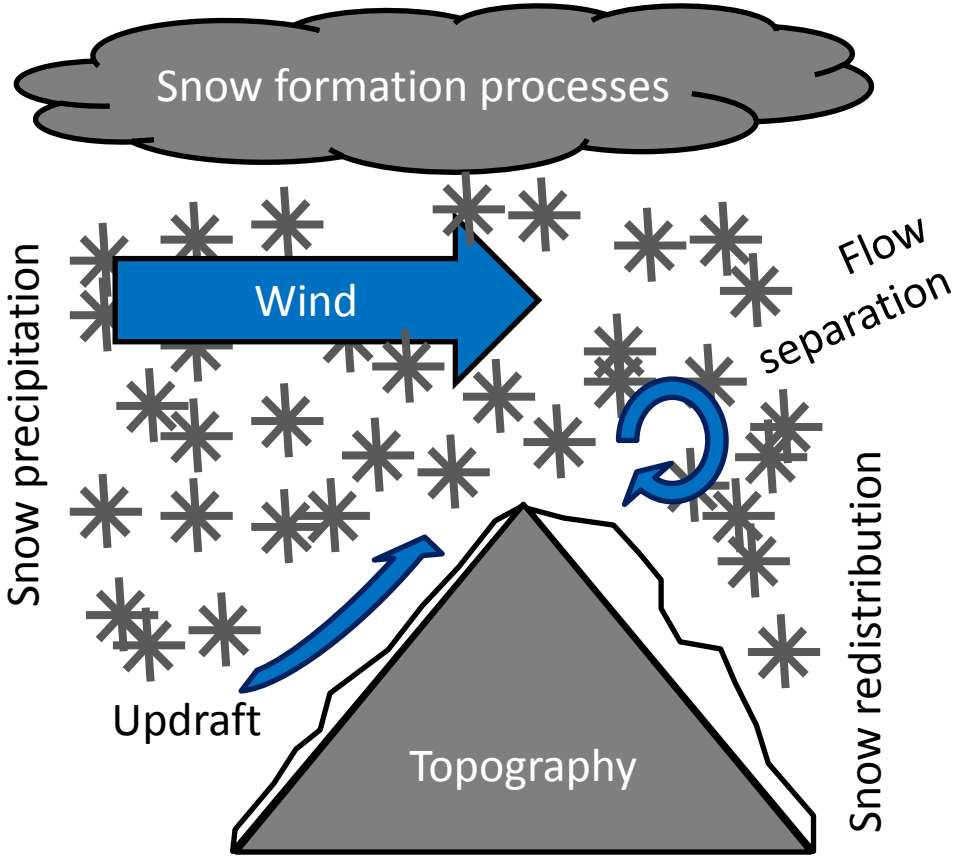


Pixmaps © 2015 swisstopo (5704 000 000)

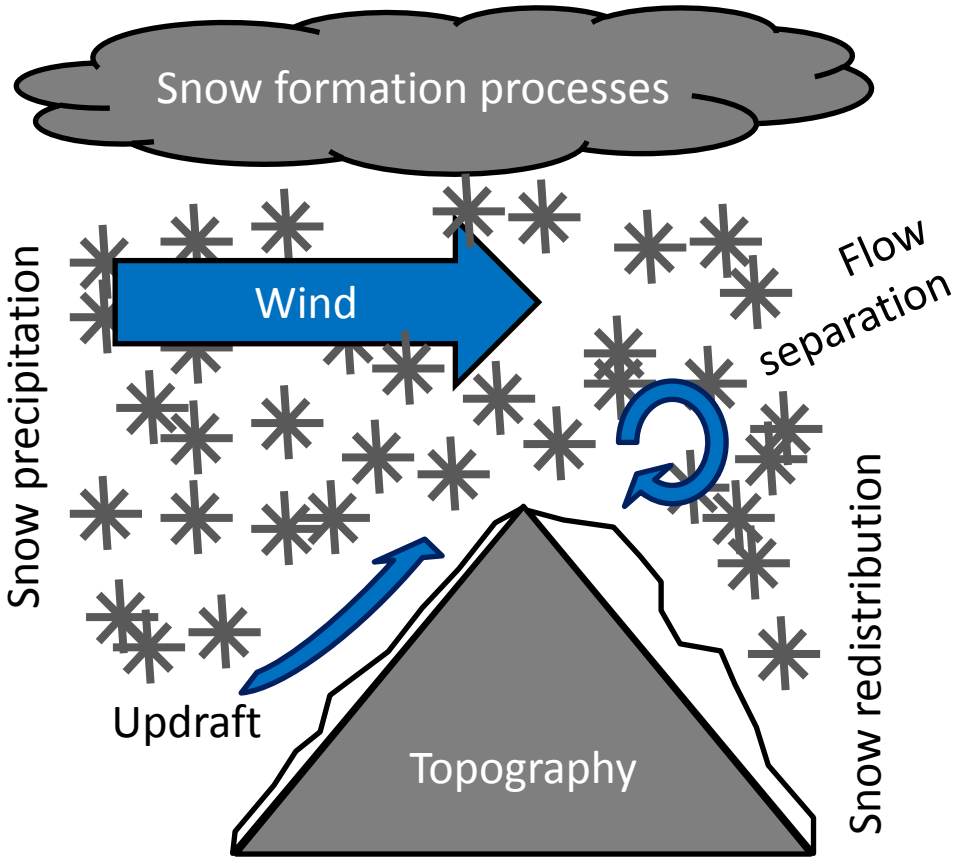
Processes: snowfall and accumulation



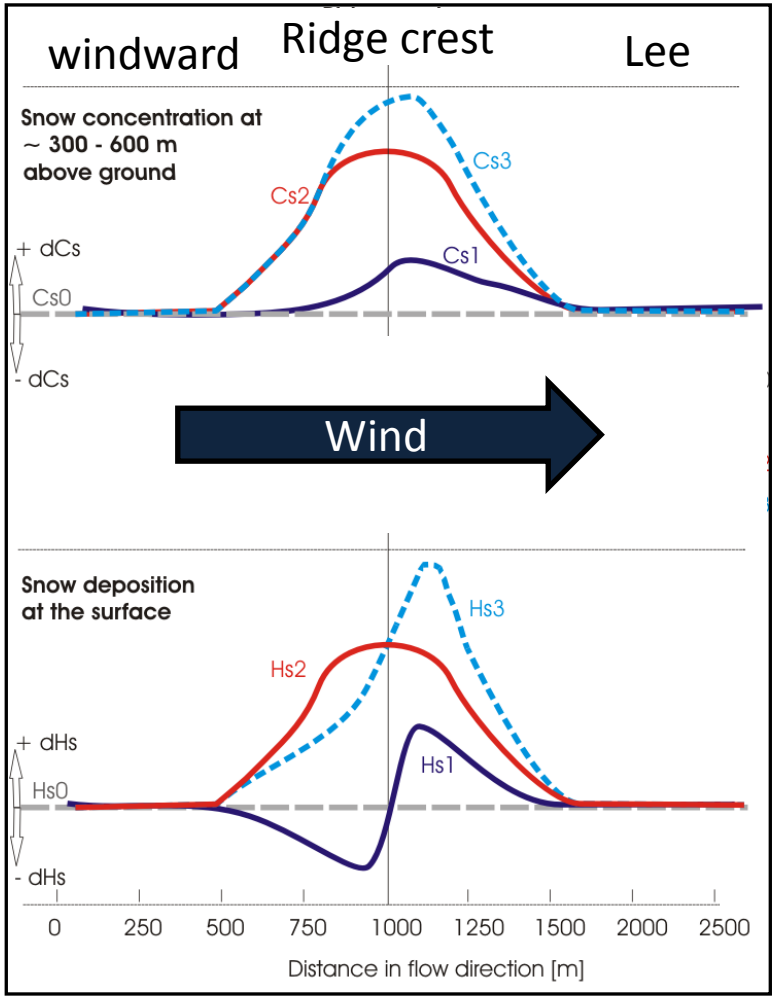
Processes: snowfall and accumulation



Processes: snowfall and accumulation



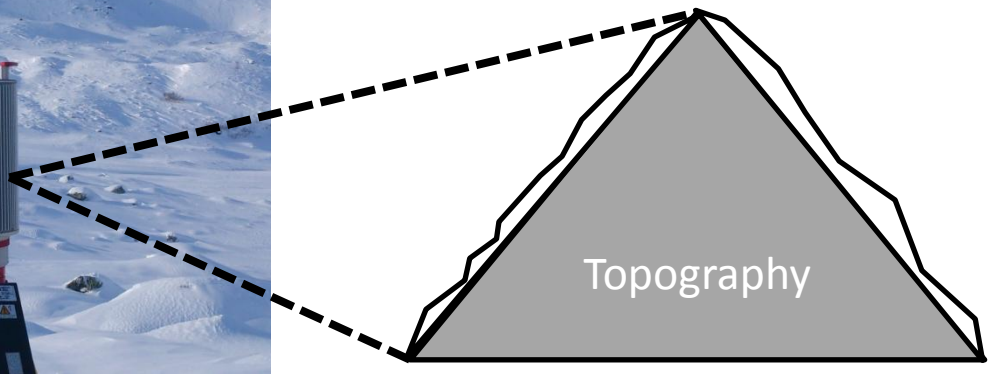
Mott et. al., 2014



CsHs0: Homogeneous precip., CsHs1: Preferential deposition, CsHs2: Seeder-Feeder Mechanism, CsHs3: combined 1 and 2

Methods: TLS before snowfall

Terrestrial laser scanning (TLS)

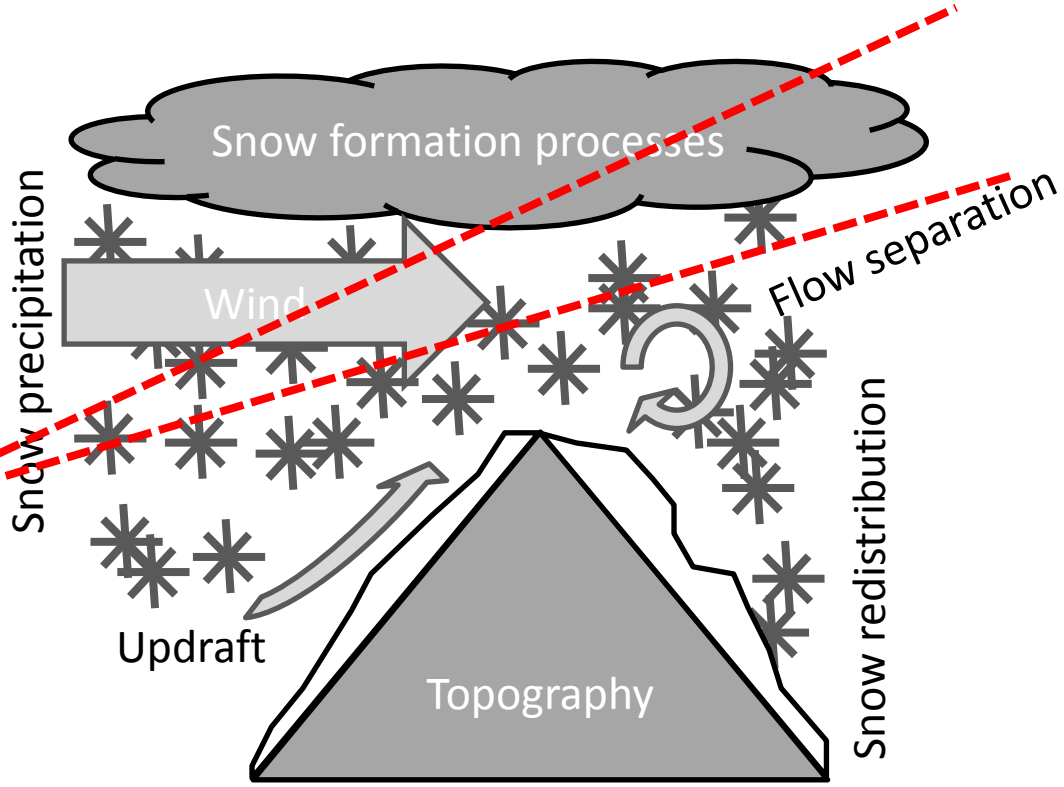


Area scanned:
- Sattelhorn: ~0.6 km^2
- Börterhorn: ~1.9 km^2

Measurements:
- VZ-6000 by Riegl
- Frequency: 150 kHz
- line/frame res: 0.007°

Radar

Polarimetric X-band radar



Snowfall rate (S_M) from radar reflectivity (Zh):

$Zh = 10\ log(Z)$

$Z = 5.07\ S_M^{1.65}$ → S_M in mmh^{-1}

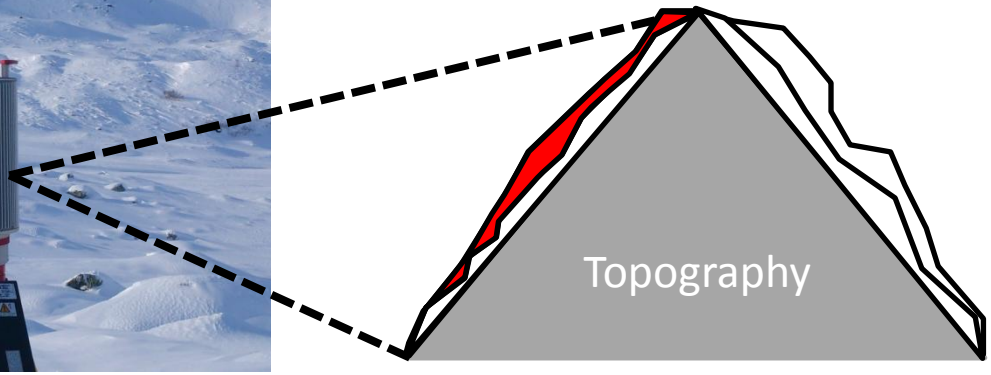
(as in Boucher and Wieler, 1985)

Measurements:

- resolution: 75 m
- time: ~5 min
- radius: ~30 km

TLS after snowfall

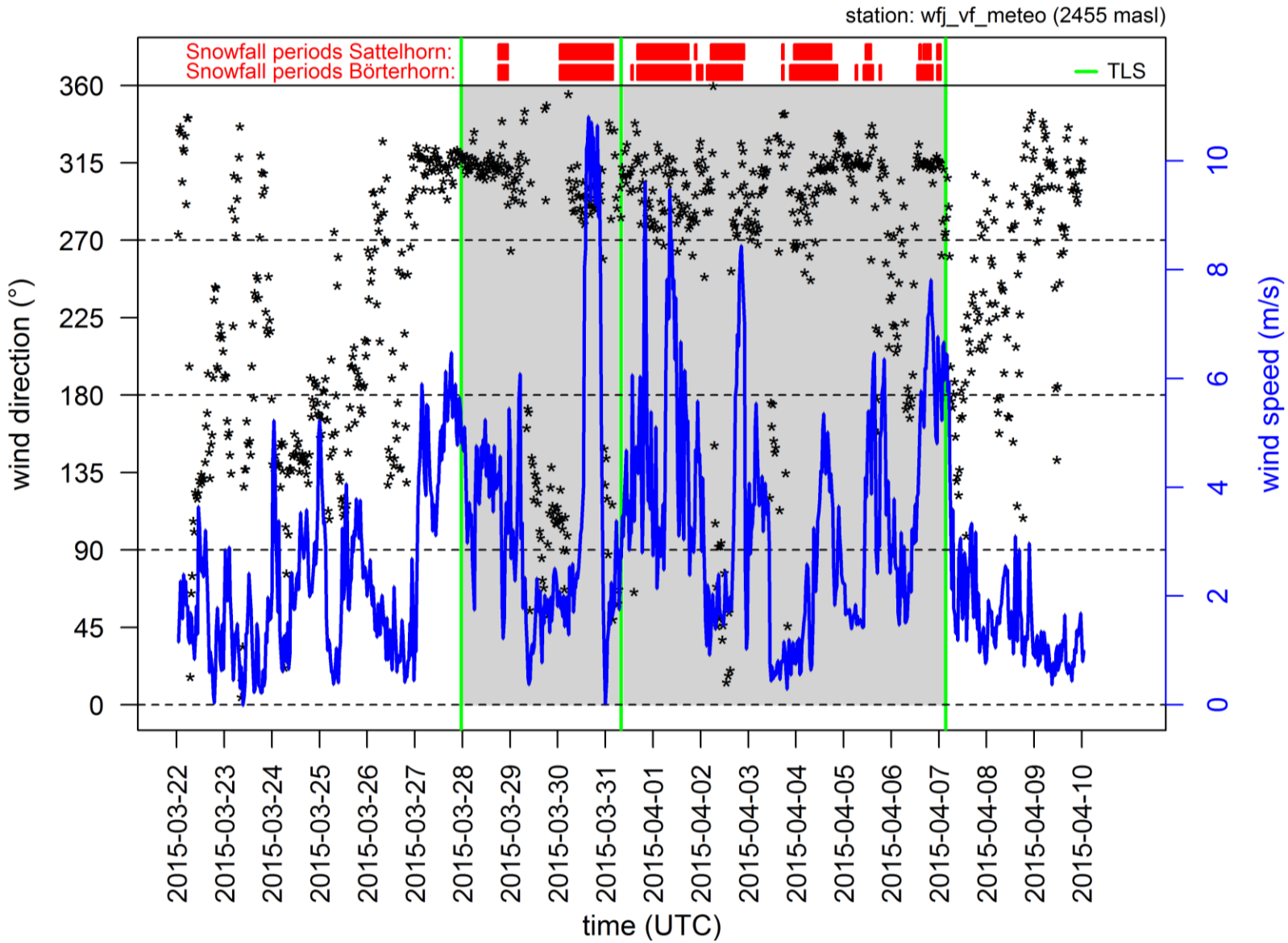
Terrestrial laser scanning (TLS)



Delta snow height (ΔSH):

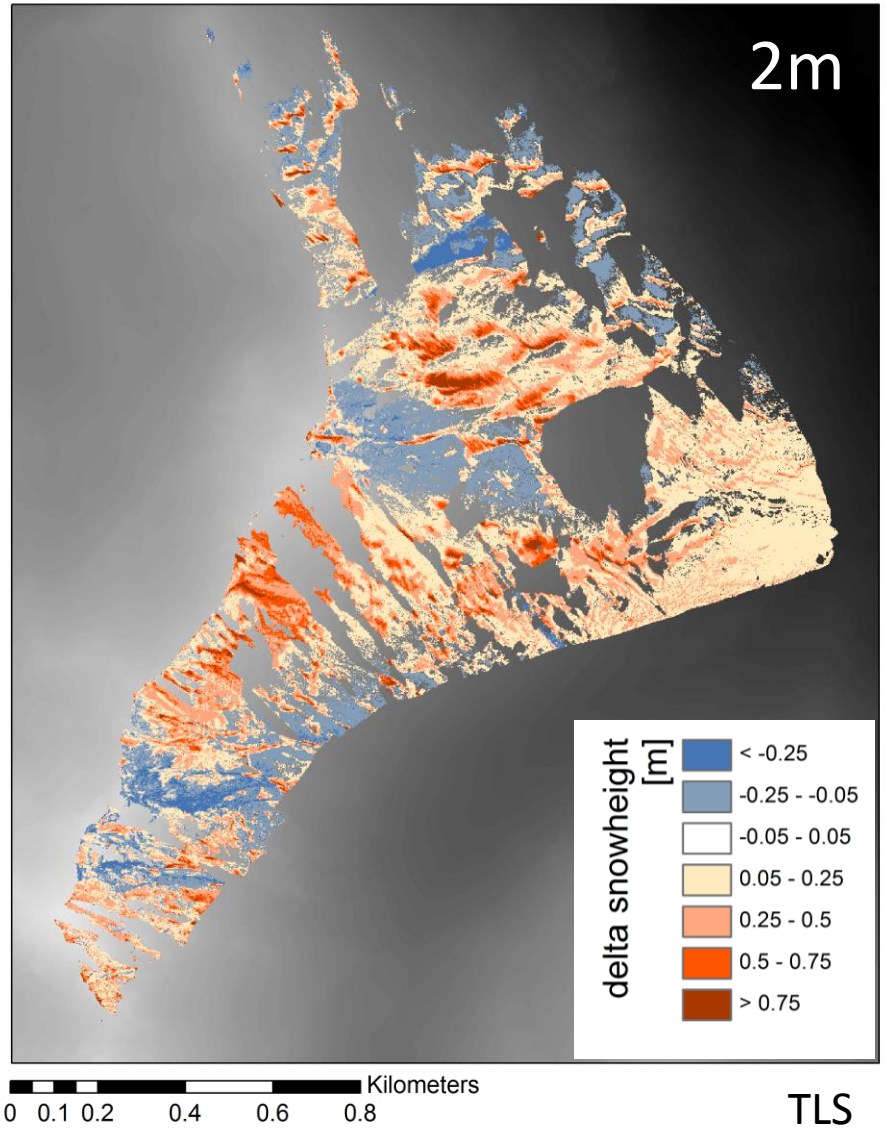
$$\Delta SH = TLS_{after} - TLS_{before}$$

Snowfall event Easter 2015: Wind

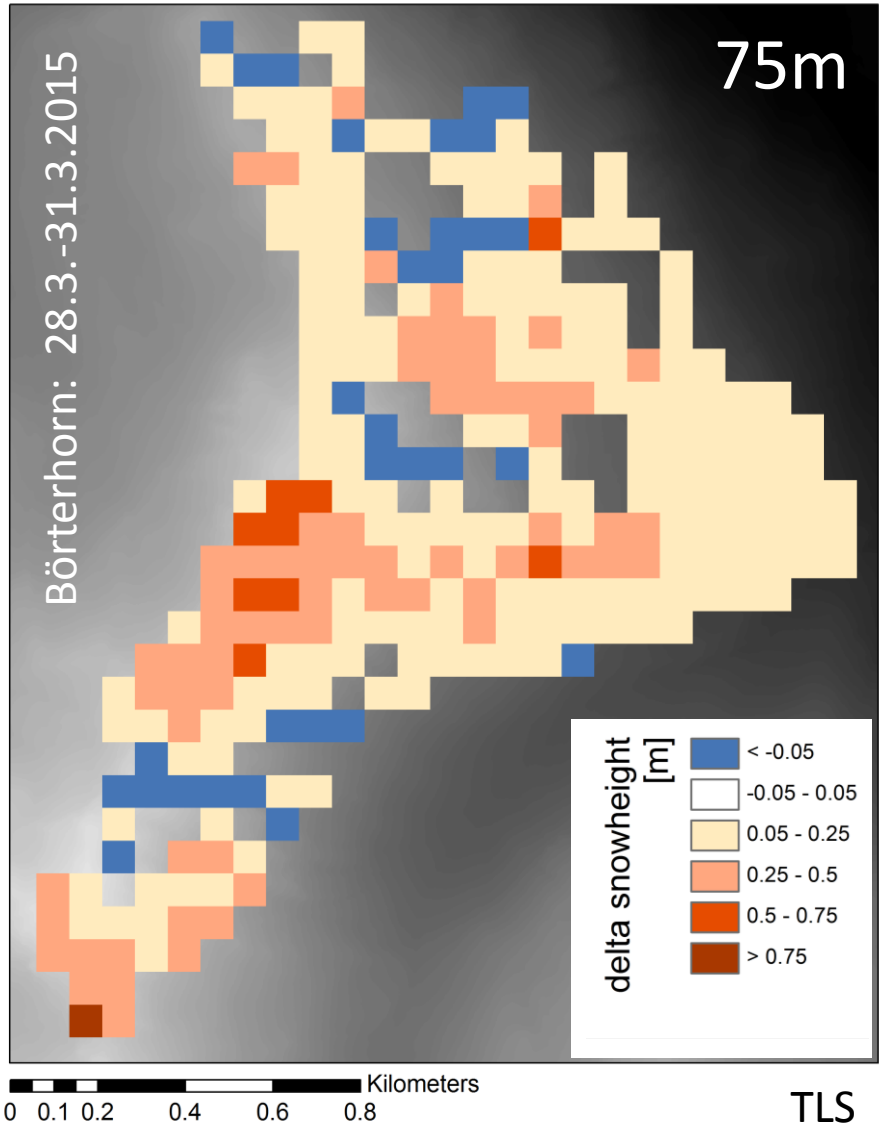


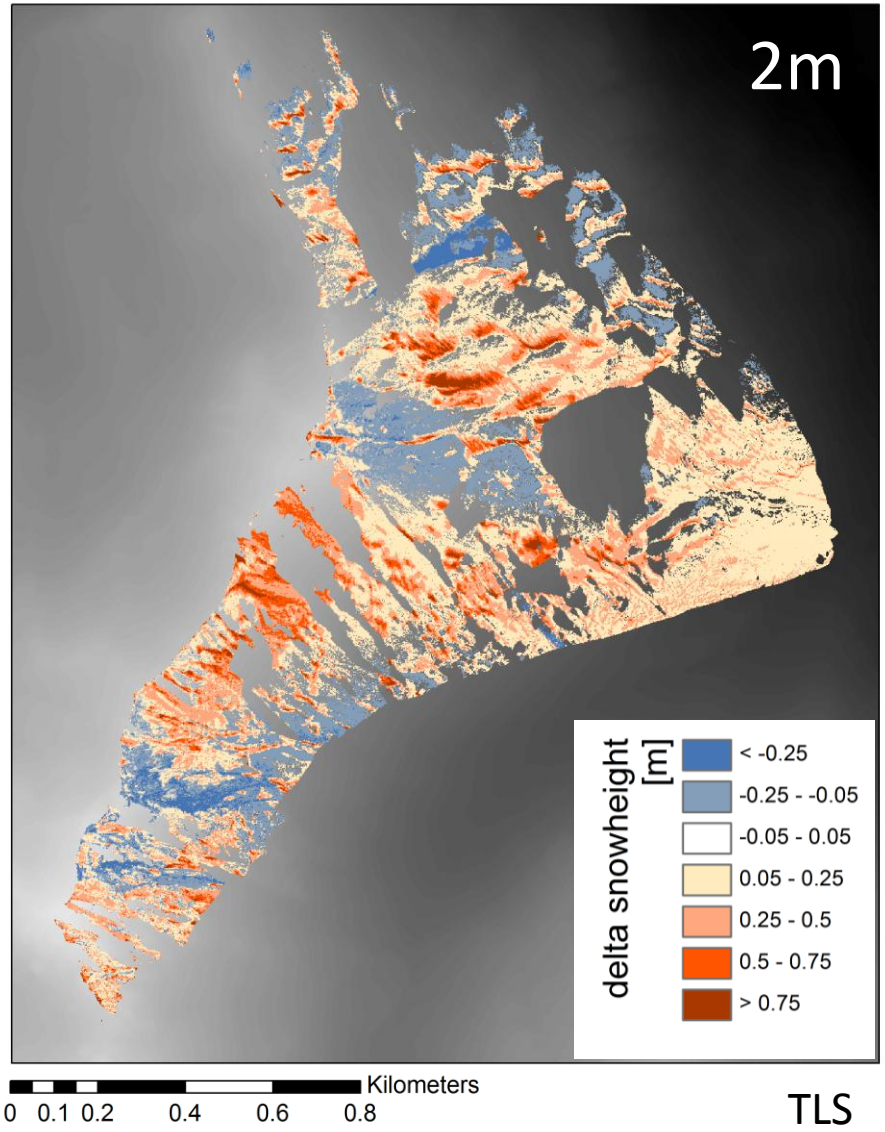
Snow accumulation - resolution

Börterhorn: 28.3.-31.3.2015

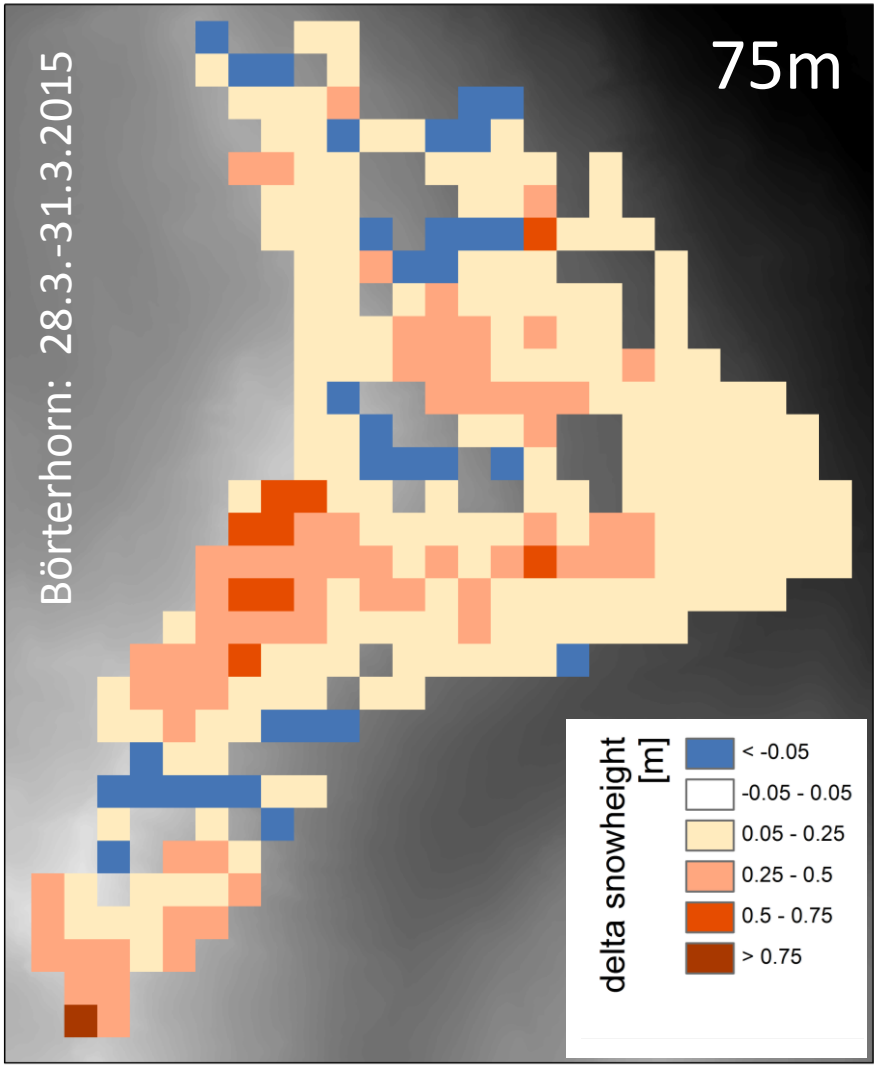


Snow accumulation - resolution

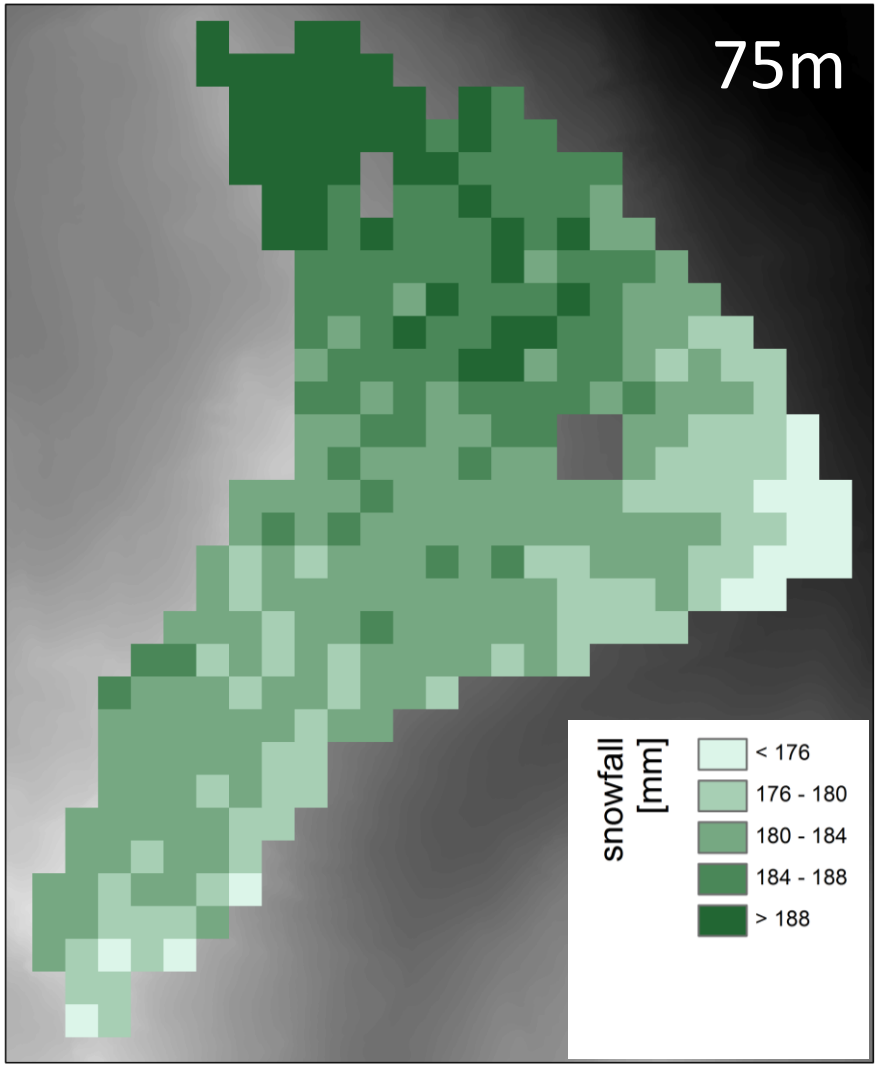




Snow accumulation vs. snowfall

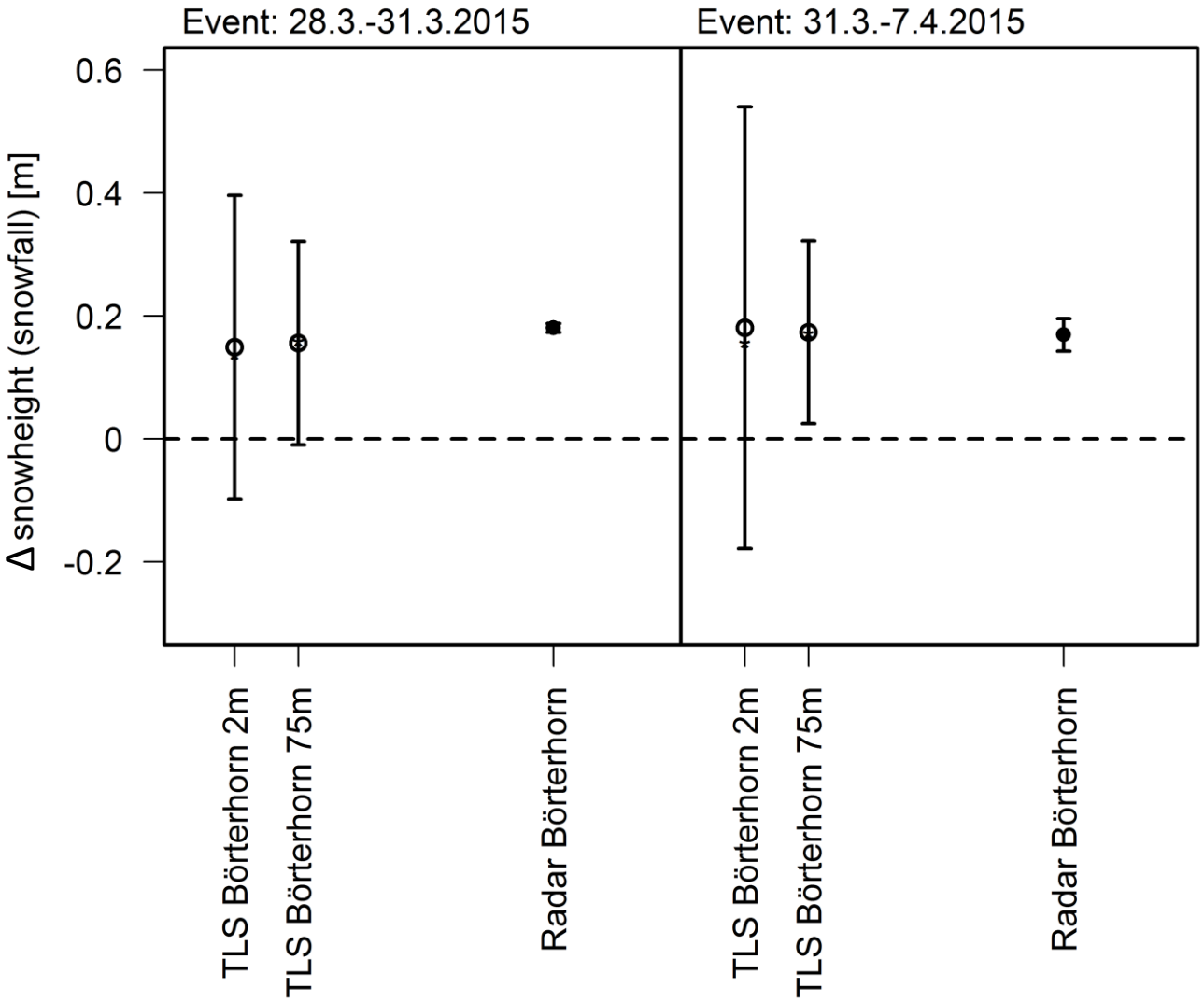


TLS



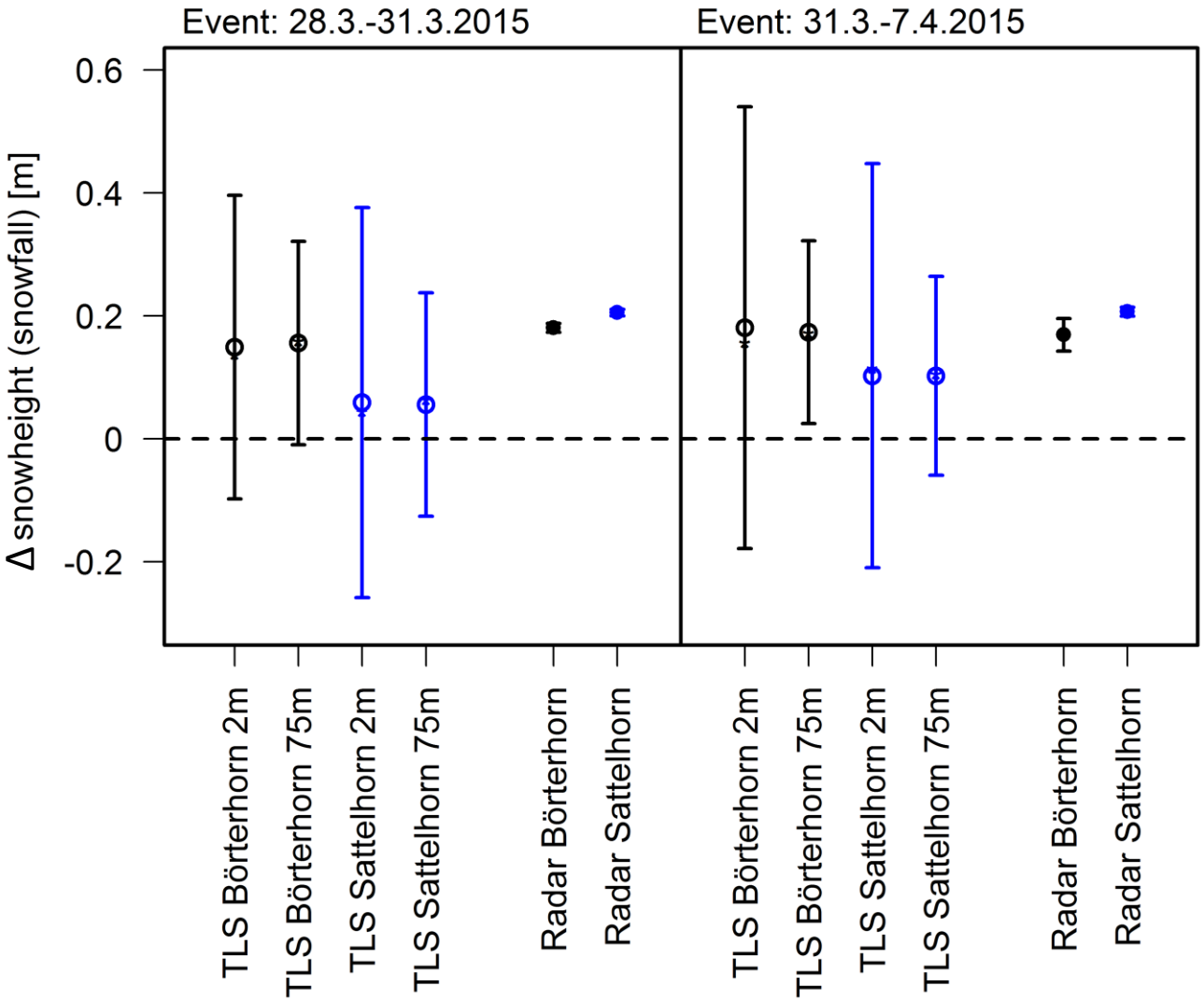
Radar

Snow accumulation vs. snowfall



- higher variability in TLS
- higher variability for 2m

Snow accumulation vs. snowfall



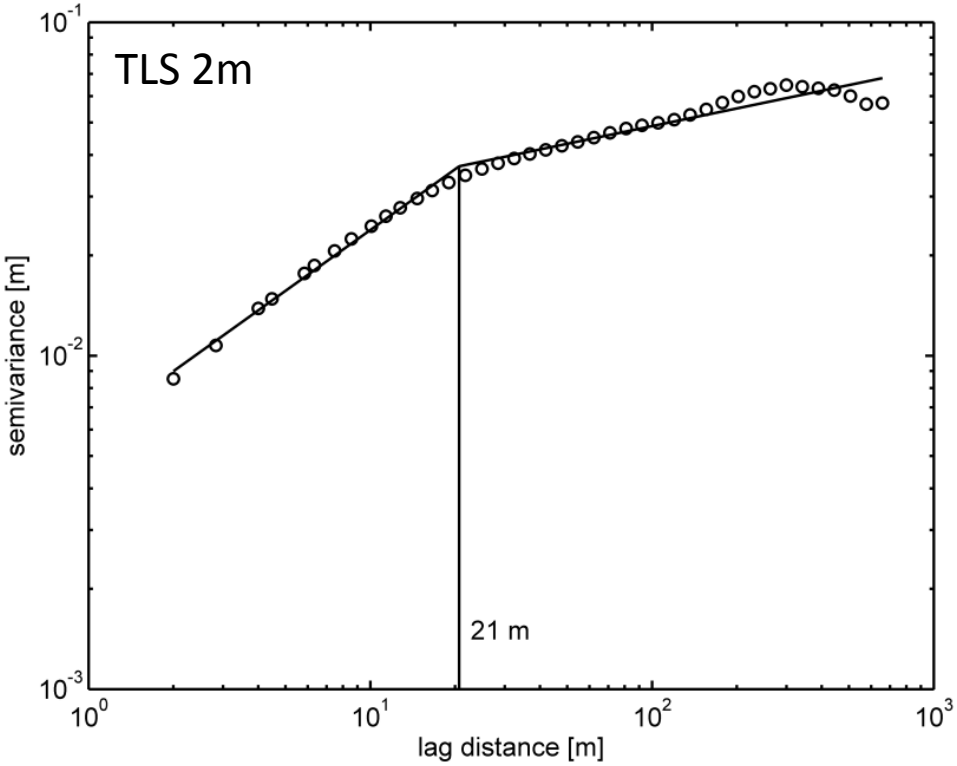
- higher variability in TLS
- higher variability for 2m

Processes in lowest 1000 m above ground:
- settling
- wind

→ Less accumulation on windward side

Dominant structures: TLS 2m resolution

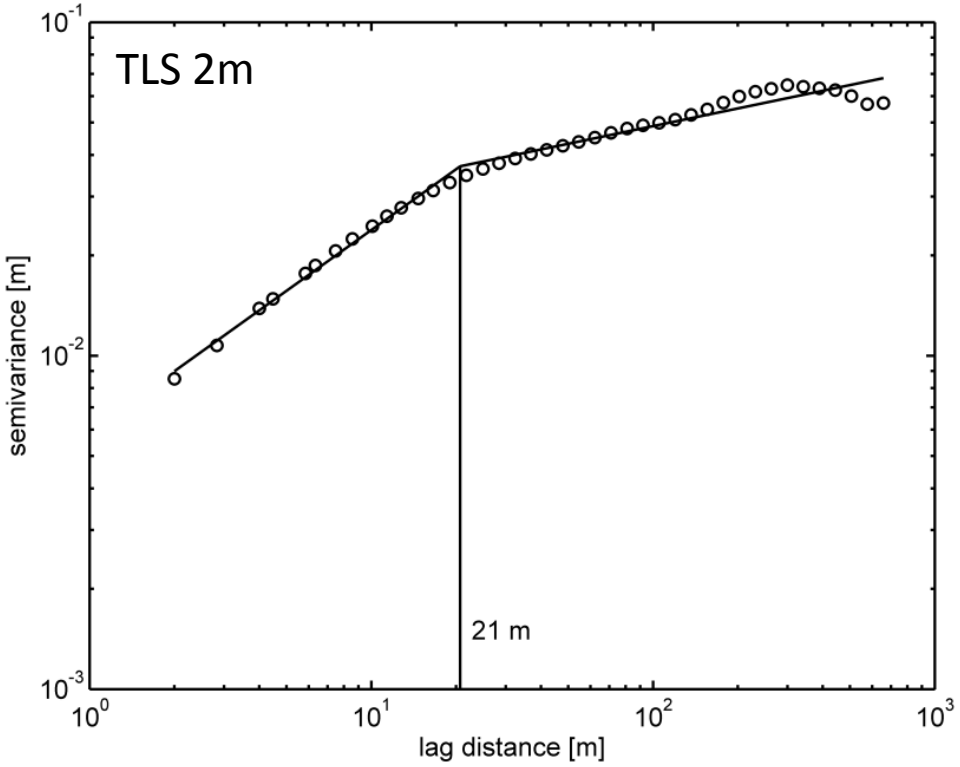
Börterhorn: 28.3.-31.3.2015



TLS 2 m	28.-31.3.15	31.3.-7.4.15
Börterhorn	21 m	6 m
Sattelhorn	118 m	21 m

Dominant structures: TLS 2m resolution

Börterhorn: 28.3.-31.3.2015



TLS 2 m	28.-31.3.15	31.3.-7.4.15
Börterhorn	21 m	6 m
Sattelhorn	118 m	21 m

Schirmer and Lehning, 2011:

lee slope: ~8m

cross-loaded slope: 18-37m

windward slope: 12-28 m

Preliminary conclusions:

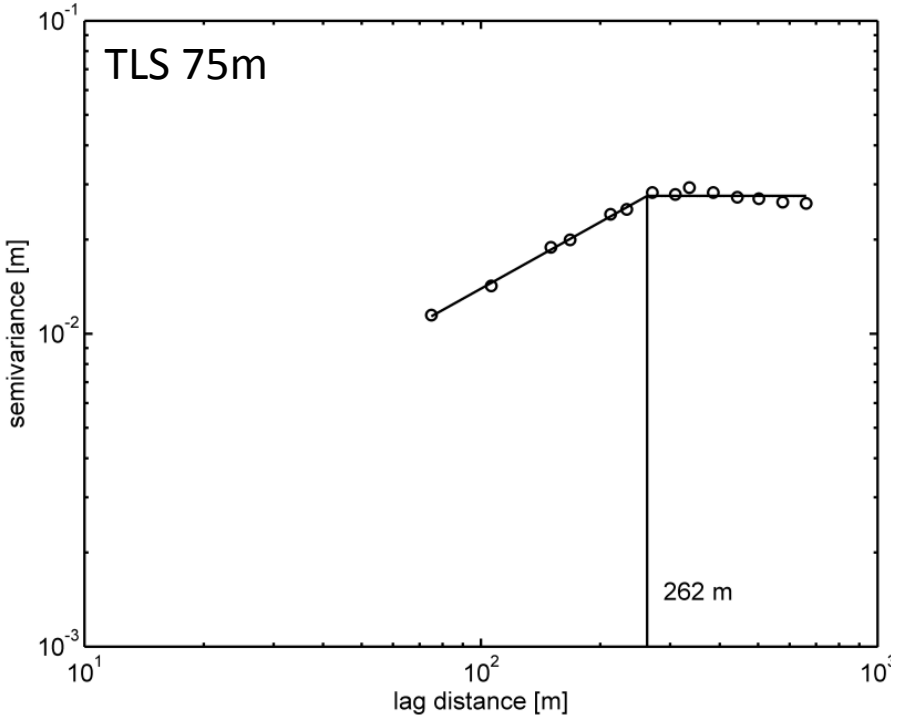
21 m and 6 m:
in range of previous studies

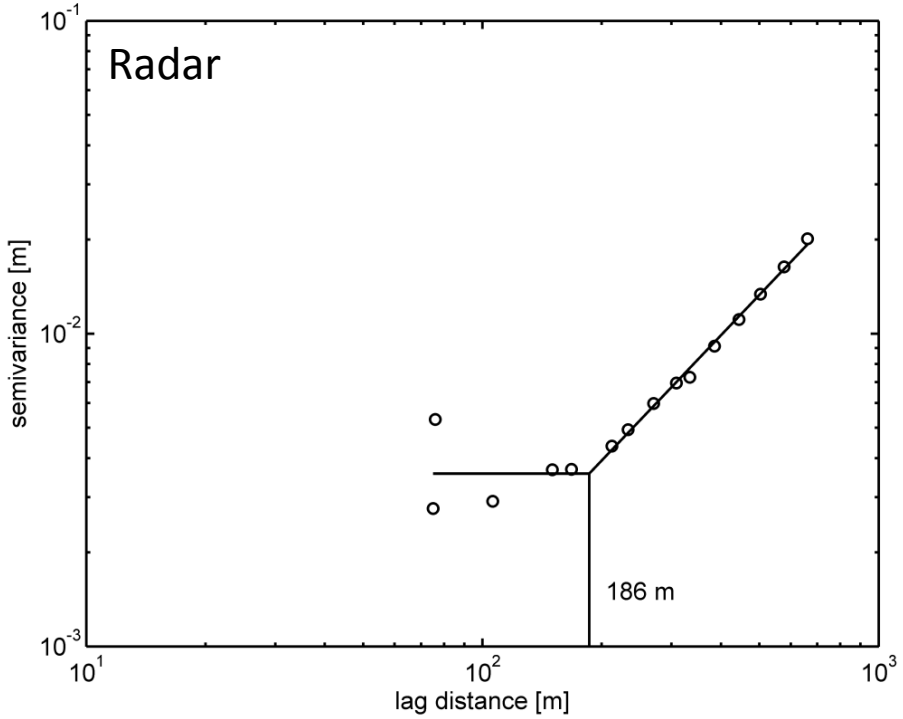
118 m: maybe effect of avalanches?

Stronger winds → smaller scales

Dominant structures: TLS vs. Radar

Börterhorn: 28.3.-31.3.2015





- Dominant structures on 75m resolution: 100-400 m
  → TLS: Scale mainly influenced by slope exposition
- Different shape for TLS and radar:
  → TLS: more persistent on small scale
  → Radar: more persistent on large scale

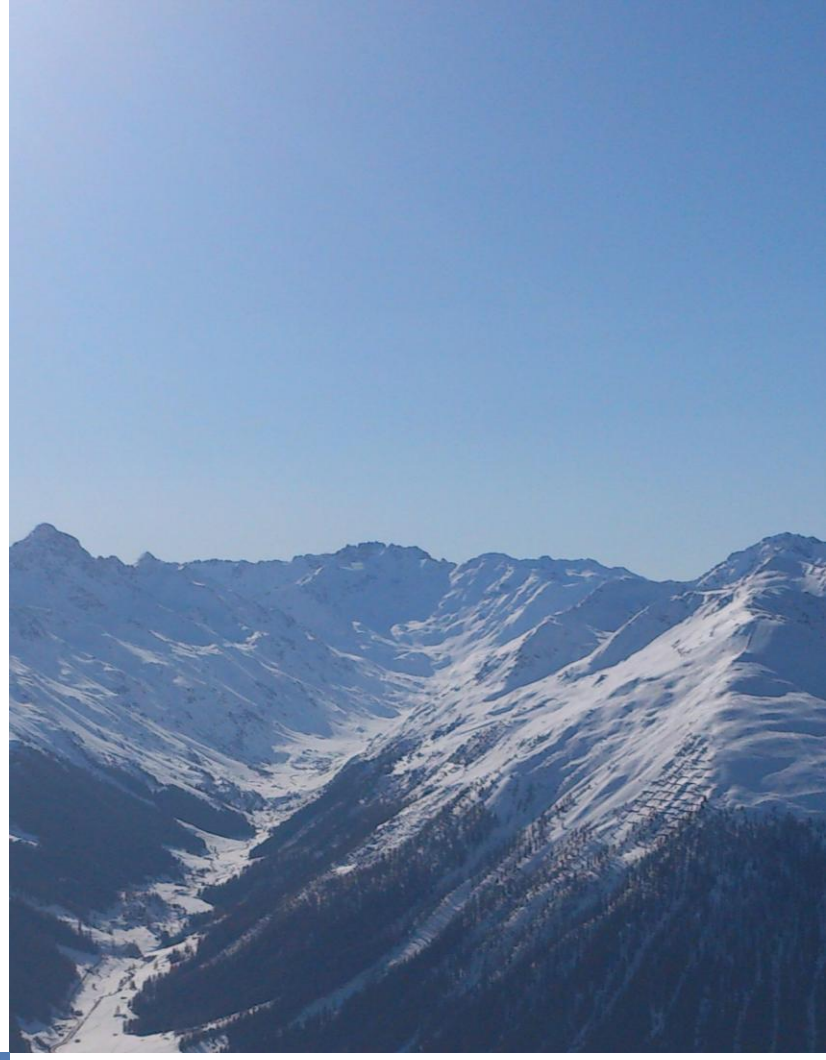
From snowfall…

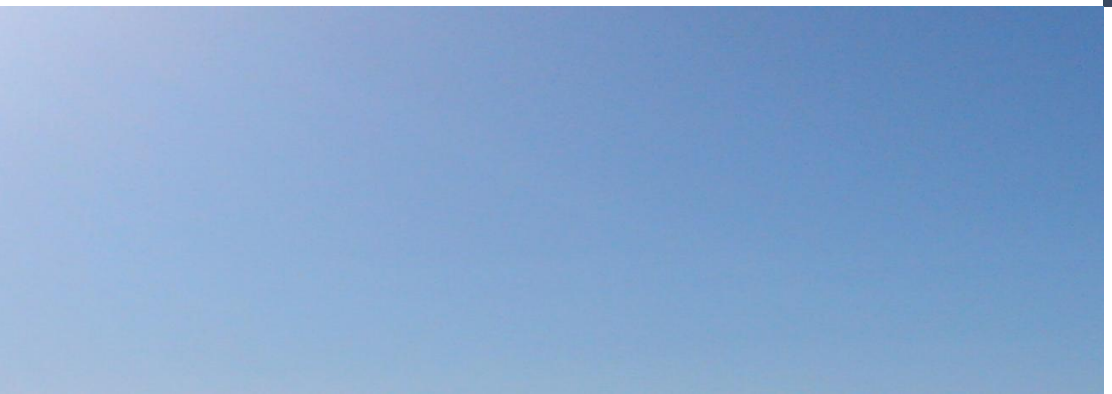
"Snowfall pattern alone can not explain snow accumulation"

"Wind and settling important"

"2m scale: wind
75m scale: slope exposition"

… to snow accumulation





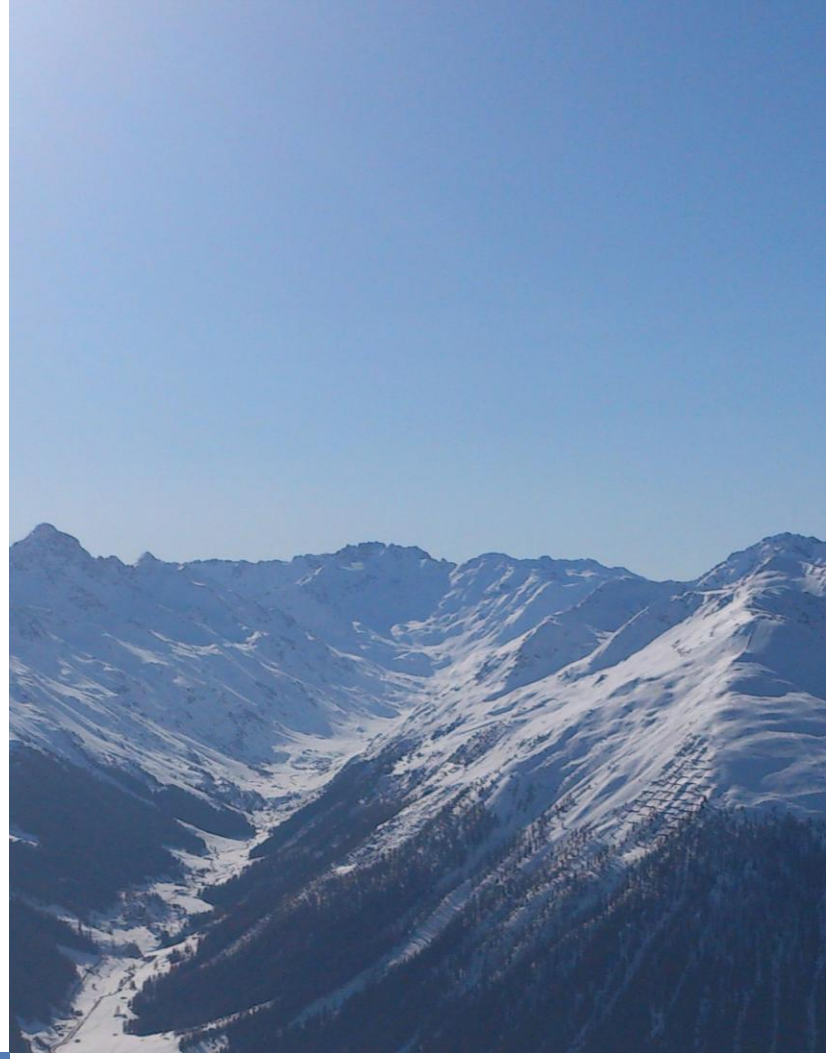
From snowfall…

"Snowfall pattern alone can not explain snow accumulation"

"Wind and settling important"

"2m scale: wind
75m scale: slope exposition"

… to snow accumulation



Thank you for your attention!

References

Boucher, R. J. and J. G. Wieler, 1985: Radar Determination of Snowfall Rate and Accumulation, Journal of Climate and Applied Meteorology, 24, 68-73.

Mott, R., D. Scipión, M. Schneebeli, N. Dawes, A. Berne, and M. Lehning, 2014: Orographic effects on snow deposition patterns in mountainous terrain, Journal of Geophysical Research: Atmospheres, 119, 1419-1439.

Schirmer, M. and M. Lehning, 2011: Persistence in intra-annual snow depth distribution: 2. Fractal analysis of snow depth development, Water Resources Research, 47, W09517.

Border of Switzerland: (accessed 20.8.2015) http://www.worldatlas.com/webimage/countrys/europe/outline/ch.htm

Map by swisstopo: pixmaps © 2015 swisstopo (5704 000 000)